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New Light on the Significance of Wet Bulb Temperature.

By F. J. W. WHIPPLE, M.A., F.Inst.P.

THE reading of the wet bulb thermometer has generally been regarded by meteorologists as a means to an end, the determination of the amount of moisture in the air, of vapour pressure and of relative humidity. We have known that in hot countries importance was attached to the wet bulb readings as giving a measure of the discomfort of a climate, but we have not asked whether a definite physical property of the air was indicated by the wet bulb reading without reference to the simultaneous dry bulb reading.

It has long been realized that if the wet bulb reading was to be used for accurate hygrometry it should be obtained with a good air flow past the bulb. The flow must be so vigorous that the heat communicated to the evaporating surface by the air is large compared with that received by radiation from surrounding bodies and by conduction down the thermometer stem. This condition is satisfied when the air flow is ten miles an hour or more; it is not satisfied as a general rule when a hygrometer is installed in an ordinary room or in a Stevenson screen. With the well ventilated thermometer the heat taken from the air provides the latent heat of evaporation of the water. According to the theory of Apjohn and August the portion of air which gives up its heat is saturated in the process. It is more correct to say that in the air streaming over the moistened bulb the diffusion of heat inwards and vapour outwards balance, and G. I. Taylor (1), who has adapted the theory of Clerk Maxwell (2) points out that it is only on account of a fortunate numerical agreement between the ratio of diffusion of heat and water vapour in air that the wet bulb serves its

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purpose so well. "Wet bulbs" moistened with liquids other than water do not conform to the same simple rules. It is to be hoped that this work of Taylor's, theoretical and experimental, will be published before long.

The point of immediate interest is that the well ventilated wet bulb does give the same temperature as is reached when the air is supplied with all the water that it can take up. This fact is demonstrated on a large scale in the installations which are supplied by the Carrier Engineering Company for humidifying or dehumidifying the air, and in which water is sprayed from fine jets into air-ducts. Given air with a certain wet bulb temperature and sprays at that temperature the product is saturated air at the same temperature. The dry bulb temperature is of no account.

Mr. W. H. Carrier (3) sums the matter up in the statement :—

> "For a given temperature of evaporation—that is, for a given wet bulb temperature—a pound of air contains a fixed and definite amount of heat, regardless of the dry bulb temperature or of the moisture contents. This means that the wet bulb temperature is the rational and convenient measure of the total heat content of the air, both latent and sensible."

Now consider the climatic problem. The skin of the healthy man in a hot climate is continually moistened by perspiration; the hot air which comes in contact with the skin takes up the moisture. The extent to which a given volume of air flowing over the skin is effective in taking away superfluous heat from the body depends on the difference between the temperature of the skin and the wet bulb temperature. The heat loss goes to provide the latent heat of evaporation and to warm up the air above the dry bulb temperature. The heat which becomes latent when a certain mass of air is being saturated is the same as the heat required to warm that mass from the wet bulb temperature to the dry bulb temperature. Accordingly the total heat loss of our perspiring human being is sufficient to warm the air from wet bulb temperature to dry bulb temperature, and from dry bulb temperature nearly to skin temperature. Evidently the dry bulb temperature is comparatively unimportant, it may even be above skin temperature (so that the second of these two processes is reversed and partially cancels the first), though in that case the amount of water which must be drunk and sweated away is excessive. The part played by the lungs in the human economy must be controlled in like fashion by the wet bulb temperature.

In a recent discussion at the Physical Society Dr. Simpson (4) gave some account of an investigation by Dr. C. W. Normand concerning the relation of wet bulb temperatures to the thermodynamics of air. Dr. Normand's paper (5), which has now been published, contains many propositions of great importance. It is shown, for example, that if two air masses start from the same sea level pressure and the same wet bulb temperature and both are carried to a higher level with no exchange of heat by

radiation, etc., they continue to have equal wet bulb temperature, and this is true to a close approximation even when condensation has begun in one air mass or in both. The fact that the wet bulb changes obey the same law, whether condensation is taking place or no, provides a criterion by which the identity of an air current may be tested. As one of his examples, Normand considers the case of a typhoon in which the central region was calm, warm and dry. The wet bulb temperature was the same in this region as in the stormy belt around it and it is concluded that the air was drawn from the same source. The same test serves to discriminate between two types of thunderstorms, the winter storms in which instability is due to the superposition of air currents from different regions, a cold current above a warm one, and the summer storms in which instability is due to processes of a local character.

The moral to which all this discussion points is that we ought to abandon the use of the more-or-less-ventilated wet bulb in hygrometry. There are two ways in which a sufficiently vigorous movement of the air relative to the wet bulb can be obtained. Either the bulb can be moved through the air or the air can be sucked past the bulb. As to the former alternative, various ways of mounting thermometers so that they may be whirled round with safety have been devised. As to the latter, the aspiration of air past the thermometer bulb dates from 1852, when John Welsh (6), later the Superintendent of Kew Observatory, devised the method for use in balloon ascents. In the well-known Assmann psychrometer (7) a clockwork fan draws the air past the bulbs.

The cost of the installation of well-ventilated wet bulbs and the additional trouble entailed in their use will be repaid by confidence in the utility of the readings and by an appreciation of their significance.

Bibliography.

A bibliography of the more important papers on hygrometry from 1783-1901 is given in the introduction to Jelinek's *Psychrometer-tafeln*, Leipzig, 1903. A selection including some later papers has been made by Dr. Ezer Griffiths in connection with the Discussion on Hygrometry, *Proceedings of the Physical Society of London*, Vol. XXXIV., Part II., Feb. 1922, p. xciv.

Taylor's formula (1) is given on p. xci. of the same Discussion and Dr. Simpson's account (4) of Normand's work is summarized on p. lxxi. Dr. Normand's paper (5) is now published as Part I., Vol. XXIII. of *Memoirs of the Indian Meteorological Department*, 1922. Clerk Maxwell's theory of the wet bulb thermometer (2) is to be found in the article on *Diffusion* in the *Encyclopædia Britannica*, 9th ed. 1877, Vol. VII., p. 218. Mr. W. H. Carrier's paper (3) *Rational Psychrometric Formulæ* was published by the *American Society of Mechanical Engineers*, Dec. 1911. John Welsh's psychrometer (6) is described in his paper, *An Account of Meteorological Observations in Four Balloon Ascents*, published in the *Phil. Trans.* of the Royal Society, Vol. XII., 1853, p. 313. References to Assman's psychrometer (7) may be found in the bibliographies mentioned above.

(The numbers refer to the figures in the text.)

The Development of Water Resources.

By M. DE CARLE S. SALTER.

THE final Report of the Water Power Resources Committee of the Board of Trade appears at a most opportune moment. The public is beginning, we believe, to awake to the fact that the present haphazard utilization of the natural water resources of the country, and the almost entire neglect of water as a source of energy for economic purposes, are not only wasteful, but in a large measure preventable. It is becoming every year more evident that we cannot afford, as a nation, to tolerate a condition of affairs which is admitted, by all who have given the matter their close attention, to be capable of considerable improvement, but which it becomes less and less possible to amend with the lapse of time.

The original terms of reference of the Water Power Resources Committee, which was appointed in June 1918, were: "To examine and report upon the Water Power Resources of the United Kingdom and the extent to which they can be made available for industrial purposes." A sub-committee was appointed by the President of the Board of Trade in November 1918 for the purpose of dealing with a similar enquiry with reference to Ireland, and although the latter body has acted independently of the main Committee, it is useful to know that the recommendations of the two, except in respect of certain legislative matters, are practically unanimous.

In October 1919, the terms of the original reference were enlarged by the following instructions: "To consider what steps should be taken to ensure that the Water Resources of the country are properly conserved and fully and systematically utilized for all purposes." The enlarged reference afforded to the Committee an opportunity of calling attention to the shortcomings of the existing system of granting powers to utilize sources of water supply which they were not slow to seize. The interests which require to be considered, particularly in England and Wales, when any water undertaking is put in hand, are numerous and complex, and amid the clamour of their uplifted voices the corporate interest of the nation is often apt to go unheard. There is no question that the Committees of Parliament charged with the duty of reconciling these interests have endeavoured to act with strict impartiality and with a commendable public spirit, but no system of changing lay administrators, even with the help of the several Acts revised for their guidance, can be expected to produce a well-balanced and co-ordinated whole.

In order to meet the need of a skilled tribunal, which shall have in mind, not only the claims of the parties immediately

before it, but the efficient administration of the whole water resources of the country in a way which would be impossible to any but experts, the Committee examined first of all the possibility of setting up a Central Water Department. It was found, however, that water interests overlapped existing Departments too much to admit of this solution. It is, therefore, proposed that there should be set up by statute a Water Commission, having jurisdiction over England and Wales, for the purpose of controlling the allocation of Water Supplies. Similar duties in regard to Water Power it is proposed shall devolve upon the Board of Trade or the Electricity Commissioners.

The duties with which the proposed Water Commissioners are to be charged are, among others, the allocation of water resources and the re-adjustment of existing allocations, always subject to Parliamentary sanction, and to render assistance to Parliament in similar duties. Secondly, to divide the country into natural areas and to appoint Watershed Boards* in substitution for the various local authorities now concerned with different water interests. Thirdly, and it is in this respect that we, as meteorologists, are mainly concerned, to carry out a complete hydrometric survey of the country.

In order to ensure the fullest co-operation between the Water Commission and the Departments interested in water matters, it is proposed to institute an Inter-Departmental Committee comprising representatives of the Departments in question and of the various scientific services. Meteorology will be represented in respect of the fundamental importance of a knowledge of the distribution of rainfall. The survey in question involves a complete tabulation of existing and potential water resources and of geological data relevant thereto, the completion of an accurate large scale rainfall map, and a study of the run-off of streams. The Committee recognizes to the full that the data demanded for the proposed survey are already partly collated and are likely to be most efficiently brought together by the experts already dealing with such subjects, and it is hoped to utilize all existing organizations and to pool available knowledge by means of Advisory Committees including representatives of the technical professions and of the scientific societies.

Special stress is laid upon the necessity of completing at the earliest possible date a trustworthy large scale average rainfall map of the British Isles. Such a map, it is pointed out, is only made possible by the voluntary work of the observers of the British Rainfall Organization. We believe that the majority of the rainfall observers have carried on their patient work with

* The snub administered to the Commission by the Director of the Ordnance Survey for misusing the word "watershed" when "river basin" is intended provides a touch of humour seldom encountered in blue books.

little thought beyond the immediate interest of the observations. Others, no doubt, have realized that their records ought, at any rate, to be utilized as data in economic problems. A few, probably, know that the collective work of the many thousands of observers has for long formed the starting point of all well-regulated water undertakings and that it constitutes the finest collection of information on a single branch of hydrology available for any country or any period. That these statistics should be appealed to, and that the general knowledge of water economy in nature which they have made possible, should be brought to bear on the present problem is inevitable.

For the purpose of getting to close grips with their subject, the Committee set out a well-devised scheme for the sub-division of the country into areas suitable for hydrometric study and water administration. It is satisfactory that as the primary basis for this sub-division the river basin is the chosen unit, rather than the county or any other administrative area. In selecting the river basins which shall be dealt with either individually or in groups, the Committee have adopted the arrangement which was designed by Dr. Mill in 1910 for use in *British Rainfall*. All the records sent to the British Rainfall Organization are now grouped in accordance with this scheme and the work of co-ordinating the rainfall survey with the general plan of the hydrometric survey should thus be immensely facilitated.

The interest of meteorologists in the work of the Committee will undoubtedly centre largely round the application of rainfall data to the solution of the problems discussed, and in a less measure the invaluable proposal to bring together the scattered and in some cases inaccessible information on the flow of streams

In regard to rainfall we are well prepared. Sufficient data exist for most of the districts in question, and where they do not exist general knowledge can to some extent supply the need. It is, however, important to point out that the areas in which direct information for water-supply and water-power purposes is most urgently needed are just those in which the population is most scanty, in other words, where rainfall stations are fewest. This difficulty becomes one of serious magnitude when we are dealing with the potential water-powers of districts like the Scottish Highlands. In these districts, the rainfall is not only very large, but extremely variable. Owing to the difficulty of supporting life in the wild glens, the population is extremely small. It is probable that the preservation of large deer-forests or other shootings may have contributed in some measure to this, but whatever may be the cause, it is extraordinarily difficult to procure rainfall records. From the actual mountains it is in most cases virtually impossible. Sufficient is

known of the natural control of rainfall to enable a very small number of mountain records to be applied to the problem of computing the mountain rainfall from that in the neighbouring glens, but these few must be absolutely trustworthy. The difficulties in the way of obtaining completely accurate records on exposed mountain slopes are greater than the inexperienced person would think, but with a reasonable amount of care and trouble it can be done. The Highland gillie makes as a rule an excellent observer and with a system of expert inspections at fairly frequent intervals, much may yet be done. It must, however, be recognised that if accurate knowledge of the rainfall of the Scottish mountain areas is to be acquired, no time must be lost. Rainfall observations for a few months prior to the launching of a great scheme are no doubt much better than nothing; but several years' records are essential if a determination of the average fall is to be free from risk of serious error.

The fact is often not fully appreciated by landowners that the water on their estates is a valuable asset and that when the time comes to utilize it, a knowledge of the amount of rainfall is of immense assistance in enabling that value to be fully realised.

The time is far spent—we would urge once more that those who have the means at their disposal for setting up rainfall observations in these remote districts which will soon become of such vital importance, will redeem it ere it be too late.

We have not dwelt upon the collateral problem of the recording of run-off of streams, because, although it is in some respects of even more importance than the rainfall problem, it is of less direct meteorological significance. In other words, the science of meteorology is concerned with the atmosphere rather than the earth and we must look to the geographer, the geologist and the engineer to provide the data which constitute the next link in the chain of Nature's water-cycle. We hope, however, to deal later with some of the practical results of the enquiry from the point of view of utilizing the flow of streams for hydro-electric purposes.

We have left ourselves little space to mention the aspects of the Report of less immediate meteorological interest. It is, however, of importance to notice that suggestions are made for the improvement of the law as to the granting of Compensation Water and that it is urged that the improvement of the inland navigation of the country should be taken in hand, more particularly in regard to the aspects in which the canal system bears upon water-supply. The interests of fisheries are also dealt with in some detail.

OFFICIAL NOTICES.

Meteorological Office Publications.

The reserve of British Rainfall, 1911, has been exhausted. The Director of the Meteorological Office would be glad to hear from any reader who has a copy which he does not require and which he could spare to be added to the stock held to meet demands on the Office.

Copies of the following issues of the Monthly Weather Report are also required:—Annual Summary, 1906; January to September, inclusive, 1907.

International Balloon Ascents.

A GENERAL scheme of dates for International Balloon Ascents for the next 7 years was fixed at the meeting of the International Commission for the Scientific Investigation of the Upper Air at Bergen in 1921. The dates for the year 1922 under this scheme were published in the *Meteorological Magazine* for February 1922, p. 20.

Attention has recently been drawn to the fact that the meeting of the members of the International Meteorological Committee in London in 1919 recommended that, as far as possible, special international investigation of the upper air should be made in co-operation with Roald Amundsen's expedition during the years 1919–1924. The following are the dates then selected for the year 1922:—

January	5th.	July	5th–7th.
February	2nd.	August	3rd.
March	8th–10th.	September	7th.
April	6th.	October	5th.
May	8th–10th.	November	1st–3rd.
June	8th.	December	7th.

These dates are to be regarded as supplementary to, and not in substitution for, the dates selected at Bergen and upper air observations should be made on these "Amundsen" dates wherever it is possible to do so without prejudice to ascents on the dates of the general scheme. It will be observed that in May the two sets of observations are practically continuous for a fortnight.

It is stated that the Lindenberg Aerological Observatory has, since 1919, arranged series of several ascents per day, the ascents being evenly distributed over the 24 hours of each day over a period of some weeks. Such frequent ascents are now being made during all the weeks which include international observations.

Official Publications.

Professional Notes No. 27.—A Gazetteer of Meteorological Stations of the First, Second and Third Order. (*Introduction and specimen pages.*) By H. N. Dickson, C.B.E., M.A., D.Sc. 10 pp. 1921. Price 4*d.* net, postage 1*d.*

DURING the war a gazetteer of meteorological stations of the first, second, and third order was prepared by the Geographical Section of the Naval Intelligence Department, Admiralty, under the direction of the late Dr. H. N. Dickson. The cost of printing at the present time being very heavy, it has been decided not to print the gazetteer but to publish the introduction and two specimen pages in order to show the kind of information available for reference.

The manuscript is kept in the Library of the Meteorological Office, and may be consulted by arrangement with the Director of the Meteorological Office.

The Royal Meteorological Society.

THE monthly meeting of the Society was held on April 19th, at 49, Cromwell Road, South Kensington, Dr. C. Chree, F.R.S., President, in the chair.

Two of the papers which were presented dealt with the investigation of the correlation coefficients between certain meteorological elements.

W. T. Russell.—The relationship between rainfall and temperature as shown by the correlation coefficient.—Mr. Russell's primary interest is in the bearing of weather on the causation of disease. The analysis of the relation between rainfall and temperature of one month, of rainfall and temperature for successive and for alternate months was carried out as a preliminary. The data utilised referred to Greenwich, Greenock, Dundee and Glasgow. The principal results obtained were as follows :—

(1) The correlation coefficient for the temperature of successive months is approximately $+0.3$.

(2) There is no definite relationship between rainfall in successive months.

(3) Rainfall in alternate months shows some fairly high correlation coefficients. For example, the coefficient found between the rainfall of June and that of August in London is as high as $+0{\cdot}55$. (As was pointed out in the discussion, this result is unexpected and must be received with caution.)

(4) There is a well marked negative correlation between rainfall and temperature in summer and a positive correlation in winter.

R. A. Fisher, M.A., and Winifred A. Mackenzie, B.Sc.—The correlation of weekly rainfall.—The rainfall at three stations, Aberdeen, York and Rothamsted having been correlated for each week of the year, the correlation coefficients were smoothed by a process involving considerable mathematical ingenuity. As was to be expected, the correlation between the rainfall at any two of the three stations is high in winter, low in summer. The ranges obtained after smoothing were as follows :—

	Max.	Week.	Min.	Week.	Mean.
Aberdeen and York - -	·64	9th	·38	28th	·53
York and Rothamsted - -	·68	6th	·49	26th	·59
Aberdeen and Rothamsted -	·53	6th	·22	24th	·37

As was pointed out by more than one speaker in the discussion, the high positive correlation obtained throughout must depend largely on the fact that all the three stations under consideration are on the eastern side of Great Britain.

Prof. S. Chapman, F.R.S., and Miss E. Falshaw, M.Sc.—The lunar atmospheric tide at Aberdeen, 1869–1919.—Prof. Chapman has previously published investigations of the tides produced in the earth's atmosphere by the gravitational attraction of the moon. He has utilised the records of Greenwich and of stations in the tropics. In the present paper the tabulations, published and unpublished, of pressure at Aberdeen have been analysed. The series of observations available was somewhat shorter than that for Greenwich—54 years as against 64 years—and as Aberdeen is more disturbed, the probable error of the result is rather greater for Aberdeen. The phases of the tide at the two stations agree as well as can be expected, while the Aberdeen amplitude, 0·0188 mb., is considerably greater than that at Greenwich, 0·0121 mb.

Correspondence.

To the *Editors, "Meteorological Magazine."*

The Sun and the Weather.

I GATHER from Mr. Deeley's letter in the March number of the *Meteorological Magazine* that he has misunderstood Father Cortie's statement concerning the characteristics of the magnetic field in 1920 and 1921. There may have been more magnetic

disturbance at Stonyhurst in 1921 than in 1920 in the sense that the mean daily range of magnetic force was greater.

The *proportional* change in the absolute value of magnetic force at any station is very small from year to year, and if the horizontal (or any other) component is increasing in one region, it is decreasing in another. Whether the earth's magnetic moment is altering at all is one of the many unknowns of science. But if it does vary, the change from year to year is certainly too small to possess significance in connection with the fate of electrons shot out from the sun.

The truth or otherwise of the assertion in Mr. Deeley's last paragraph is at present a matter of opinion.

C. CHREE.

Kew Observatory, Richmond, April 1922.

Weather Lore.

I NOTICE in the March number of *The Meteorological Magazine* that Commander Brooke Smith suggests the Bristol Channel above Minehead as a good place to study the variations of wind with tide. In a letter written to this Magazine in September 1919, I gave some of the chief phenomena in connection with wind and tide in that district, from experience gained at all times of the year and in all weathers. It is essential to be on the sea to notice the changes, as frequently there is no apparent variation on shore. However, on occasions of little wind, it very often happens that the progress of the flood-tide up Channel can be followed from the cliffs by watching the advancing line of "wind-billow," on the surface of the sea, coming from west or north-west; the wind comes up about the time a boat at anchor begins to swing to the "young flood," after the "slack" of low-water.

Of course, most of these changes can best be noticed during the summer months. The curious thing is their variety—westerly winds up Channel appear usually to freshen on the flood, although in the case of sea-breezes from west-north-west to north-west the tendency is just the reverse. Easterly winds are more constant, and usually freshen on the ebb, especially inshore, although some miles off the coast this is not very apparent.

These remarks refer wholly to about twenty miles along the west Somerset coast. Changes in the temperature of the water, and friction, undoubtedly contribute to these phenomena, but the temperature differences must be very small.

T. F. TWIST.

Fawley, Hants. March 31st, 1922,

Solar Halo observed at Eskdalemuir, March 15th, 1922. An Arc of Unrecognized Character.

THE halo illustrated on the plate opposite was observed at 10h. 45m. on March 15th. The sky at the time was about half-covered with cirro-stratus and thin haze. The cirro-stratus took the form of thin parallel bands running approximately east-north-east to west-south-west, while immediately below it there appeared to be another layer of a cirro-stratus type taking the form of a very thin haze.

The halo was of good definition and the following points were noted :—

(*a*) Parhelia appeared on both sides of the circle, but not within its circumference, the left or eastward of these being considerably brighter than its fellow.

(*b*) An ill-defined arc of contact with upturned ends could at times be seen at the top of the circle.

(*c*) At the bottom, the halo was exceedingly brilliant and showed colours ranging from orange on the inside of the ring to pale green on the outer edge.

(*d*) About midway between the eastward parhelion and the bottom of the circle a down-turned arc joined the circumference on the outer edge.

The arc was distinctly visible for some 20 minutes. Not until 11h. 5m. did a thickening of the ring on the westward side give any indications of a corresponding arc. The thickening which was similar to that observed in the solar halo* of 20th April 1921, was unmistakable, but it was not possible to distinguish any definite arc.

The halo continued visible for nearly an hour, but the parhelia and arcs disappeared and fracto-stratus finally intervened.

Measurements were made by aligning the sights of a pilot balloon theodolite. The principal dimensions were as follows :—

Elevation of the sun	29° 1.
Radius of the halo	22°
Elevation of the intersecting arc	18° 9
Radius of the intersecting arc (the centre being the lowest point of the halo)	22°

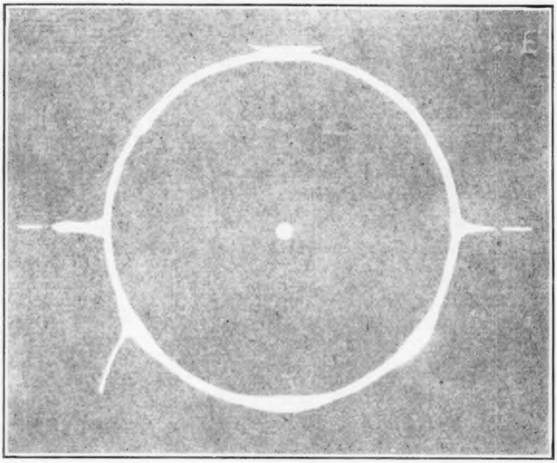
P. F. JARROLD.

Eskdalemuir Observatory, April, 1922.

[The arc observed by Mr. Jarrold is new to us. It does not occur in the comprehensive paper : *On the Arc of Lowitz and Allied Phenomena,*† by S. Fujiwhara and S. Oti, which includes the examples collected by Bravais, Pernter, and Besson as well

* *Meteorological Magazine,* Vol. 56, June 1921, p. 128.

† *Bulletin of the Central Meteor. Obsy. of Japan,* Vol. III., No. 1, 1919.



A SOLAR HALO OBSERVED AT ESKDALEMUIR.
MARCH 15TH, 1922.

AN UNUSUAL CLOUD STRUCTURE OBSERVED AT FELIXSTOWE.
MARCH 1ST, 1922 (*see p.* 105).

as recent illustrations from the United States *Monthly Weather Review*.—Ed. M.M.]

Unusual Wind Structure at Eskdalemuir.

Two pilot balloon ascents at Eskdalemuir on the morning of March 25th disclosed a wind structure of some interest, close to the trough of an elongated depression which extended from beyond the Hebrides to eastern England. At 7h. 30m. there was a west-north-west current up to 8,000 feet, the highest velocity being 11 miles per hour at 2,000 feet. Above 8,000 feet the wind backed quickly, and from 11,000 feet upwards it was south-south-east, increasing in velocity up to 40 miles per hour at 17,000 feet, where the balloon was lost. Nephoscope observations of cirrus-cloud motion showed that the velocity increased still further at greater heights, without appreciable change of direction. Three hours later the wind structure was similar, except that the lower wind was lighter and began to back about 5,000 feet; above 13,000 feet the wind had backed 10° since 7h. 30m. A computation of the horizontal gradient of temperature between 4 and 5 kilometres (13,100 and 16,400 feet) above mean sea level, based on the wind structure disclosed by the second balloon, showed that the mean temperature between these levels fell towards south-west at the rate of 2·7° C. per 100 kilometres, or 7·8° F. per 100 miles. The explanation of this temperature gradient can readily be seen from the synoptic charts. Over the south-western half of the British Isles there was a cold north-westerly current with heavy hail showers and local thunder, and these conditions always mean very low temperatures aloft. Over the North Sea there was a south-south-east current which was also cold at the surface, but up above one would expect to find air originally from the "warm sector" of the cyclone. The cyclone had recently become surrounded by polar air, and it began to fill up 12 hours later. Just behind such elongated depressions there is normally a strong upper current from south-south-west or south, but only rarely from south-south-east. There are, however, some cases on record of wind structure similar to that of March 25th.

C. K. M. Douglas.

March, 30th, 1922.

[The method of computation mentioned by Capt. Douglas is due to Sir Napier Shaw.* It is based on the principle that if the wind aloft differs from that below there must be a corresponding difference in the pressure distribution and that this is due to the lower layers being colder and denser in one region than in another. The air aloft goes cyclonewise round a cold area.—Ed. M.M.]

* *Manual of Meteorology*, Part IV, Chap. VII. *See also* Q.J.R. Met. Soc. 1914, Vol. XL, p. 112.

NOTES AND QUERIES.

The Gale of March 7th—8th, 1922.

THE autographic records on the opposite page have been reproduced in order to show further details of the gale of March 7th–8th, which was described in last month's magazine, p. 81.

An interesting feature is the second rise in wind speed at Pendennis Castle between 5h. and 6h. Neither Scilly nor Plymouth records show this. There is no corresponding change in wind direction, but a rise in temperature is associated with the increased wind velocity. The temperature rise occurs shortly before the increase in velocity in each case.

The highest gusts recorded were 48 metres per second (108 miles per hour) at 3h. 40m., at Scilly, and 46 metres per second (103 miles per hour) at 3h. 30m., at Pendennis Castle.

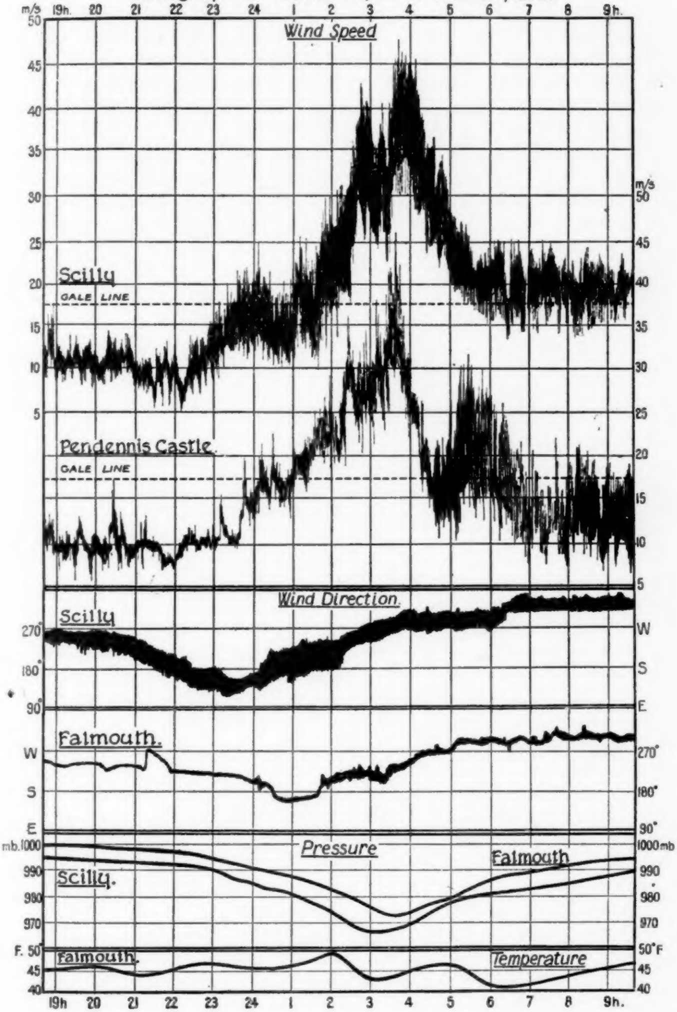
The gust at Scilly is the highest ever recorded in England and the highest but one recorded in the British Isles.

The gust at Quilty, Co. Clare, on January 27th, 1920, which carried the pen beyond the edge of the chart, indicating 110 miles per hour, is accepted as the highest on record. This excursion of the pen was isolated, however, and there is room for doubt as to its interpretation. It should be mentioned also that the pressure-tube anemometer at Scilly is not in exact adjustment and that the curves have not recently been accepted for the wind analysis for the *Weekly* and *Monthly Weather Reports*. The error, which displaces the zero by two or three miles per hour, may affect the record at the top of the scale by such an amount.

The Abnormal Distribution of Sunshine during March 1922.

THE distribution of sunshine during March 1922 shows some interesting irregularities. The normal map of sunshine for March indicates a gradual decrease from 4·5 hours per day along the south coast of England, to less than 3·5 hours per day in western Scotland and northern Ireland; also relatively high sunshine along the east coasts of Scotland and England. During the month under review, the highest values obtained generally in the west and north-west, thus constituting an almost complete reversal of type. An examination of the pressure map throws light on the anomaly, the highest pressure being found to the west of Ireland and the lowest over the North Sea. The high sunshine values over Ireland thus coincide with

Autographic Records, 7th-8th March, 1922.



the anticyclonic area, but the explanation only partially suffices. The deficiency of sunshine around Moray Firth, along the Yorkshire coast, on the north coast or Norfolk and around the coast of Kent is significant; in fact, east coast stations with a northerly or north-easterly aspect have low sunshine values. On the other hand, where the aspect is south-east the sunshine is greater, relatively high values being found around the Firth of Tay and along the coast of Essex. A similarity of distribution may also be seen in the Isle of Wight. The northerly and north-easterly winds which largely predominated after the first week of the month appear to have been associated with much cloud in those districts where they struck the coast at right angles. The most sunny place in the British Isles was Turnberry on the Ayrshire coast, with 5·2 hours of bright sunshine per day, whilst at Scarborough there were only 2·3 hours per day.

A Comparison of Rain Gauge Sites.

THE need for great care in the selection of rain gauge sites is well brought out in an investigation which is being carried out at the Royal Air Force Marine and Armament Experimental Station, Isle of Grain, Kent. Originally, the rain gauge was exposed on a bank or ridge, the height of which was 5 to 6 feet above the water-level on the east and 11 feet above the level ground on the west. The ridge runs north and south along the seashore, *i.e.*, on the east coast of the "island."

It was found that the rain measured at Grain was considerably lower than at neighbouring stations, and over-exposure was suspected. A new gauge was therefore installed at the beginning of the year, and measurements from the two gauges compared. The new gauge is 50 yards inland on nearly level ground; this ground, like the slope of the bank, being covered with coarse, long grass.

In January 1922, the new gauge gave 59.5 mm. against 45.6 mm., in the old, while the figures for February are 33.4 mm. in the new and 26.3 mm. in the old gauge. It is found that with light winds the agreement is good, but with stronger winds a marked discrepancy occurs, more especially with winds having an easterly component.

The hyetograph, which was originally exposed near the old gauge, was transferred to the new site at the end of February; in January, the hyetograph recorded 39.9 mm. as against the 45.6 mm. of the old gauge, while for the eight days in February, when it was in its new position, it gave 14.1 mm. as against 15.4 in the new gauge.

An unusual Cloud Structure.

THE unusual cirrus formation illustrated on the plate facing page 100, was observed by Mr. D. F. Bowering at Felixstowe, at 6h. 30m. G.M.T. on March 1st. No other cloud was visible except this wave-like structure consisting of cirro-stratus at the thicker parts and of cirrus at the ends; it was situated due south of the station at an angle of 45° from the horizon. A nephoscope observation gave the speed-height ratio as 8 radians per hour from south-west, so that on the assumption that the height of the cloud was 5 miles, the speed must have been about 40 miles an hour.

Both horizontally and vertically the details of this structure were clearly defined and detached and the waves were apparently equidistant from each other with the sky blue between. The outside sections were identical with each other both in structure and formation. Shortly afterwards the sky began rapidly to cloud over and at 7h. it was more than half covered with strato-cumulus; some cirro-stratus was also visible and was found to be moving at about 45 miles per hour from the west. Mr. G. A. Clarke of Aberdeen, who has seen Mr. Bowering's report, states that the phenomenon is rare and that the cloud type is more akin to cirro-cumulus than to true cirrus. He himself observed a very similar case on December 8th, 1911, at 10h. when the waved bands were very extensive, the lowest was continuous, the middle one partially so and the uppermost broken. The direction of the cirrus cloud was west by south and the lie of the band corresponded fairly well with the direction of the wind which sprung up later in the day, reaching force 7 at 23h. The cloud band faded away in a few moments and at 10h. 5m. only a few broken lines showed. Mr. Clarke points out that the spaces between the sets of cloudlets in Mr. Bowering's example would just hold another wave so that they may have been parts of a continuous waved band. It is a coincidence that in each case the band was triple.

The Travels of a Balloon.

DURING a "Shopping Carnival" week in December, 1921, at Thrapston, Northamptonshire, rubber balloons were released for advertising purposes. On the 12th to 14th of December balloons filled with pure hydrogen were used, and on December 20th one of these was picked up in a field near Cremona in Italy, at a distance of approximately 800 miles from Thrapston. Unfortunately it is not known on what date the balloon fell.

From the 12th to 16th of December, southern England and France were situated between two anticyclones. One extended

from the Bay of Biscay to the Azores; the other was established over Poland and south-eastern Europe. France and England were more under the influence of the former than of the latter.

During this period pilot balloon ascents over England and France show winds mainly from between north and north-west. On the evening of the 12th, at Cranwell in Lincolnshire, a wind of 17 miles per hour from north-west at an elevation of 7,000 feet was recorded; at the same time Calshot recorded a wind of 18 miles per hour from the same direction at 6,000 feet.

On the 13th at Pulham there was a wind of 13 miles per hour from north by west at 6,000 feet and at Lympne, a wind of 5 miles per hour from west by north at 4,000 feet. On the 14th, Rennes in north-west France had a wind of 22 miles per hour from north-north-west at 5,000 feet and on the morning of the 17th, Friedrichshafen had a wind of 23 miles per hour from west by north at 9,000 feet. It will be seen that the evidence is consistent with the travel of a balloon from Thrapston to Italy. There are no other pilot balloon ascents which add to our information of the upper currents during the period of the balloon's journey, but the nephoscope observations at Valencia and Eskdalemuir between the 12th and the 15th of December show a strong northerly wind near the cirrus level.

The interest shown in this incident suggests that it would be desirable to have labels on all pilot balloons, to be detached and returned by post to the meteorological stations. At present only the places at which *ballons sondes* are recovered are reported.

Underground Water Level.

To judge by the present condition of the chalk wells at Detling to the north of Maidstone, it is practically certain that there will be hardly any yield of water during the coming summer. Regular observations, covering a period of nearly 40 years, of the water level in a well at the Croft, Detling, show that the saturation level is usually highest between mid-March and mid-April, and is succeeded by a gradual decline to the lowest position in November or December. On March 1st of this year the saturation level was only 3 inches above the well bottom (the well is 112 feet in depth, in chalk throughout) and the well became entirely dry on March 21st, a condition of affairs which is still maintained, though it has never before occurred, at this season, during the past 70 years. It is on record that the supply failed in 1858, and again in 1902; the well was dry throughout December of the latter year, a rise set in, however, during the first week of 1903, and by mid-April the saturation level was

10 feet above the well bottom. In another well, half a mile south-west of the Croft, dug in the chalk and just reaching the gault at a depth of 63 feet, the yield failed on October 3rd, 1921, the well continuing dry to March 20th, 1922. On March 27th 2 inches of water were recorded, 18 inches on April 3rd, 24 inches on April 10th, and 25 inches on April 17th. On April 24th the water had fallen to 15 inches, showing a definite decline in the saturation level of 10 inches. SPENCER RUSSELL.

Records at Falmouth for 1921.

Meteorological Notes and Tables for the Year 1921 has been received from Falmouth Observatory. The pamphlet, which has been prepared by Messrs. W. L. Fox and J. B. Phillips, is published by the Royal Cornwall Polytechnic Society. During 1921, at Falmouth, pressure, sunshine and temperature were above the average, rainfall was considerably below the average and there was a marked frequency of northerly winds.

The maximum temperature, 82·8° F. on July 18th is the highest ever recorded at Flamouth, a temperature of over 80° F. having been reached only four times since 1885.

A New Laboratory for Work on Atmospheric Pollution.

THROUGH the kindness of Professor H. B. Baker, F.R.S., a room in the Imperial College of Science and Technology has been placed temporarily at the disposal of the Meteorological Office. The Office has fitted up the room as a laboratory for the use of the Advisory Committee on Atmospheric Pollution. There is an ante-room which may be used as a photographic dark-room, while the room itself is well equipped with apparatus, including facilities for glass-blowing. This new laboratory will be of great assistance in the work on atmospheric pollution.

British Association Meeting, 1922.

THE meeting of the British Association will take place this year at Hull, September 6th to 13th. Mr. M. A. Giblett (Meteorological Office, Air Ministry, Kinsgway, W.C.2) will again represent Meteorology on the Committee of Section A (Mathematics and Physics), as a Secretary of that Section.

Obituary.

Henry Newton Dickson.—Dr. H. N. Dickson, whose death occurred on April 2nd, was born at Edinburgh in 1866. He studied at the University of Edinburgh and gained much practical experience in physiography by voluntary work in connection with the *Challenger* expedition, the Scottish Marine Station, and the Ben Nevis Observatory. In 1891 he investigated the salinity and temperature of the English Channel for the Marine Biological Association at Plymouth, and in 1893 he joined the lecturing staff at Oxford. While there he continued the work which he had started at Plymouth, extending his researches to cover the North Atlantic. In 1901, with the co-operation of the Meteorological Office, Dickson produced his most important work, *The circulation of the Surface Waters of the North Atlantic Ocean.** From 1906–1920 he was professor of geography at University College, Reading, and during the war he placed his wide experience at the service of the Intelligence Department of the Admiralty, where he prepared an important series of handbooks descriptive of those regions in which military operations were either occurring or likely to occur. His last work was in the Editorial Department of the *Encyclopædia Brittanica,* on the additional volumes for the 12th edition.

Dickson published two useful text-books, *Elementary Meteorology*, which appeared in 1893, and *Climate and Weather,* 1912. He also devoted much time to the study of the underground water in the chalk formations near London and an important investigation of evaporation from an exposed surface, for which he had devised an automatic recording evaporimeter, was interrupted by the outbreak of war.

During 1911 and 1912 Dickson was President of the Royal Meteorological Society. It had been evident for some time that the development of the Meteorological Office and its *Monthly Weather Report* had rendered necessary a reconsideration of the work of the Society, which had been a pioneer in the collection of climatological observation from its Fellows. Dickson recognized the need for ending the duplication of work and publication, and devoted himself to the arrangements by which the responsibility for the collection, reduction and publication of the climatological records was transferred to the Meteorological Office. To effect a break of this kind and, at the same time, to prevent a weakening of the Society and its activities required great tact and judgment. But the Society was numerically as strong afterwards as before and the improvement in the quality of the *Quarterly Journal* which followed the change was patent to all.

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* *Roy. Soc. Phil. Trans.* A. 196, 1901.

Dickson had a great fund of humour and it was always a pleasure to get a seat next to him at the dinners of the Meteorological Club at the old Westminster Palace Hotel. He had, moreover, an enthusiasm for meteorology and had begun to get students at Reading to do research work in the subject, when the war came and closed, for the time, that field of enterprise. E. G.

News in Brief.

The Council of the Royal Astronomical Society has decided to issue special supplements to the *Monthly Notices*, containing papers of geophysical interest which have been submitted to the Society and which may or may not have been previously read at the Discussions. The Discussions will continue to be published in the *Observatory*. Non-members of the Society who wish to receive these supplements are invited to apply as soon as possible to the Assistant Secretary, Royal Astronomical Society, Burlington House, London, W.1, stating whether they desire a regular supply or not. The price will depend on the number and length of the papers printed, but will not for the present exceed 10s. per annum.

On April 7th, two aeroplanes on the London-Paris Service collided in the fog near Beauvais. Seven lives were lost, including those of the two pilots, Mr. R. E. Duke and M. Jean Mire. Owing to the fog, the machines were flying at less than 600 feet. This accident has caused considerable discussion of methods for guiding pilots in bad weather, and on April 14th, a conference of British and French pilots and airway managers was held at Croydon. It is gratifying to learn that from 1919 to September 1921, over 142,000 passengers were carried and only 12 have been killed.

News is received that the two Portuguese aviators, G. Coutinho and T. S. Cabral, who were attempting the 4,000 mile flight from Lisbon to Rio de Janeiro, encountered heavy weather and were forced on April 19th to land on the St. Paul's Rocks, about 550 miles from the Brazilian coast, with the result that the seaplane was too severely damaged to continue the journey. The Portuguese Government have sent out another seaplane and it is hoped that the flight may be resumed.

Sir Ross Smith, who flew from England to Australia, was to have attempted the flight around the world but, while testing the machine for this purpose at Brooklands on April 13th, he

and his engineer, Lieut. J. N. Bennet, were killed. The death of this distinguished aviator is greatly to be deplored.

The death is announced at the age of 81 of Mr. Adolphus Collenette, Director of the States Meteorological Service, Guernsey. We hope later to publish an obituary notice.

Dr. G. C. Simpson has been elected a member of the Athenæum Club under the provisions of a rule of that club which empowers the annual election by the committee of a certain number of persons of distinguished eminence in science, literature or the arts, or for public service.

The following note appears in a return of observations from Kilkenny:—"Owing to the Castle being occupied by armed forces and the instruments in the line of fire, it was impossible to take readings for the two days, May 3rd and 4th."

During the partial eclipse of the sun on March 28th, 1922, temperature in the shade at Malta dropped from 62° F. to 55° F.

The Weather of April, 1922.

In north-western Europe, April was for the most part a cold, unsettled month. At the beginning of the month, the chief feature of the pressure distribution was the existence of two large areas of high pressure, one between Iceland and Spitzbergen, the other over Madeira and southern Spain. These two highs persisted with little change for the first fortnight. Between these anticyclones a series of depressions moved in from the Atlantic, crossing the British Isles or their vicinity, and causing the prevalence of very unsettled conditions over northwest Europe.

During the first eight days of April, stations in the Azores reported some heavy falls of rain. On the 1st, Ponta Delgada recorded 72 mm., and Horta 26 mm., while on the 8th, Horta had 50 mm.

On the 3rd of the month, a deep depression moved up the Channel causing easterly gales in the Channel accompanied by heavy precipitation and low temperatures on the northern side of its track, particularly in southern England and the midlands. Continuous rain, sleet or snow fell in most localities. Kew reported a rainfall of 14 mm., and Croydon 18 mm. in the 24 hours, while on the Continent, the Helder and Flushing each had 73 mm. The maximum temperature for the day was only 33° F. at Malvern, 34° F. at Ross-on-Wye and 35° F. at Hampstead. By the 4th, this depression was over Germany, causing rain or snow there and in southern Scandinavia. Unsettled weather was maintained over the British Isles until the 14th. The warmest weather of the month was experienced in the south of England on that day, and was due to a supply of warm air on the southern side of a depression centred to the south of Ireland. The temperature at Kew Observatory on that day reached 67° F.

This depression, which deepened as it passed to the north of Ireland and thence to the North Sea, caused strong winds and gales, with heavy rain in places, over the British Isles and on the southern coasts of Norway. The full force of the gale was felt in the English Channel, where considerable structural damage was done in places and shipping held up. On the 15th

the warm air had reached Germany, where Berlin had a maximum of 81° F.

In the rear of the depression the northerly wind current caused a marked drop of temperature over the British Isles, the maximum temperature at Kew on the 16th being only 50° F.

The squally northerly winds persisted over western Europe for a day or two with rain and hail showers over a wide area, and on the 17th temperatures failed to exceed 45° F. at many places in Denmark, Scotland, and parts of France, but reached 70° F. at Vienna, 75° F. at Warsaw and 77° F. at Posen.

The northerly current decreased and an anticyclone spread in from the west, and by the 18th extended from the Azores to Scandinavia. This high-pressure system continued in the form of a ridge from the Azores to Scandinavia for three or four days, although decreasing in intensity, and gave generally fair weather in the British Isles and western Europe, with sharp night frosts in many localities. On the 20th, Renfrew recorded a maximum of 61° F. and Eskdalemuir one of 60° F.

By the 22nd, a shallow depression had formed over south-east England causing a break up of the fine weather.

On the 23rd a depression over Iceland deepened and moved in a south-easterly direction, and by the evening of the 24th it was over the North Sea causing rain in most districts of western Europe.

This was followed by another depression moving in from the Atlantic, and on the 25th and 26th a large low-pressure system, within which were several well-marked centres, covered the area around the British Isles.

Considerable variations of temperature were associated with this distribution of pressure. For example, on the 18h. chart of the 25th the temperature at St. Ann's Head, in the warm sector of one of the depressions, was 48° F. whilst at Holyhead, in the cold sector, the temperature was only 41° F. Next morning much snow was lying on the hills of Shropshire and Central Wales though there was only a sprinkling on the top of the Black Mountains in Breconshire.

On the morning of the 26th, the centre of the low area was over the southern North Sea, whence it moved to Denmark and then to Scandinavia. The northerly winds in its rear continued until the end of the month accompanied by occasional hail or rain showers and local thunder.

A depression centred over the Gulf of Lyons on the 28th moved north-eastwards, and by the morning of May 1st it was over Scandinavia. In its passage it caused heavy rain in parts of France, Switzerland, Germany and Denmark. On the 30th, temperature rose to 72° F. at Vienna and to 70° F. at Prague.

In southern Europe the weather for the whole of the month was fine with very little rainfall, conditions which also prevailed in the eastern Mediterranean. Temperatures exceeding 100° F. were twice recorded at Cairo during the month, 104° F. on the 16th, and 102° F. on the 21st.

W. C. K.

Heavy rains in Switzerland at the beginning of the month caused a serious landslide near Le Bouveret (Valais) in the Rhône Valley. The village of Les Evouettes was partially buried. Floods were subsequently reported from all parts of the country and also in the Rhône Valley in France. At Lyons the lower part of the town was under water. There was a considerable amount of minor damage by avalanche and landslide owing to the continued rainfall.

At the end of the month the Seine was high. Floods were feared in the Toulouse neighbourhood where torrential rain fell throughout the 29th.

(*Continued on* p. 116.)

Rainfall Table for April 1922.

STATION.	COUNTY.	Aver. 1881—1915.	1922.		Per cent. of Av.	Max. in 24 hrs.		No. of Rain Days
		in.	in.	mm.		in.	Date.	
Camden Square	*London*	1·54	3·02	77	196	·53	3	17
Tenterden (View Tower)	*Kent*	1·62	3·10	79	191	·53	12	18
Arundel (Patching Farm)	*Sussex*	1·75	3·73	95	213	·92	3	16
Fordingbridge (Oaklands)	*Hampshire*	1·83	3·30	84	180	·76	13	18
Oxford (Magdalen College)	*Oxfordshire*	1·54	2·61	66	169	·48	13	19
Wellingborough (Swanspool)	*Northampton*	1·49	3·19	81	214	·49	25	18
Hawkedon Rectory	*Suffolk*	1·54	2·84	72	184	·63	25	18
Norwich (Eaton)	*Norfolk*	1·71	2·49	63	146	·52	25	15
Launceston (Polapit Tamar)	*Devon*	2·34	4·83	123	207	·65	15	20
Sidmouth (Sidmount)	,,	2·13	2·91	74	137	·69	13	20
Ross (County Observatory)	*Herefordshire*	1·89	2·68	68	142	·63	3	19
Church Stretton (Wolstaston)	*Shropshire*	2·16	3·15	80	146	·71	25	18
Boston (Black Sluice)	*Lincoln*	1·35	2·28	58	169	·55	5	17
Worksop (Hodsock Priory)	*Nottingham*	1·47	2·86	73	195	·46	25	20
Mickleover (Clyd House)	*Derbyshire*	1·73	2·83	72	164	·49	25	19
Southport (Hesketh Park)	*Lancashire*	1·85	1·54	39	83	·30	12	17
Harrogate (Harlow Moor Ob.)	*York, W. R.*	1·84	3·15	80	171	·45	12	17
Hull (Pearson Park)	,, *E. R.*	1·56	1·55	39	99	·24	15,23	18
Newcastle (Town Moor)	*North'land*	1·64	2·02	51	123	·51	14	17
Borrowdale (Seathwaite)	*Cumberland*	7·42	3·85	98	52	..	..	..
Cardiff (Ely Pumping Stn.)	*Glamorgan*	2·53	3·47	88	137	·62	25	23
Haverfordwest (Gram. Sch.)	*Pembroke*	2·62	4·42	112	169	1·07	1	18
Aberystwyth (Gogerddan)	*Cardigan*	2·61	2·53	64	97	·72	25	5
Llandudno	*Carnarvon*	1·81	2·24	57	124	·59	12	17
Dumfries (Cargen)	*Kirkcudbrt.*	2·67	2·63	67	98	1·23	14	13
Marchmont House	*Berwick*	2·02	2·32	59	115	·82	14	12
Girvan (Pinmore)	*Ayr*	2·97	3·48	88	117	1·36	14	19
Glasgow (Queen's Park)	*Renfrew*	1·97	1·70	43	86	·85	14	13
Islay (Eallabus)	*Argyll*	2·87	3·10	79	108	·95	14	16
Mull (Quinish)	,,	3·30	3·41	87	10	·81	14	19
Loch Dhu	*Perth*	4·74	6·00	152	127	2·80	14	9
Dundee (Eastern Necropolis)	*Forfar*	1·70	1·55	39	91	·82	14	15
Braemar (Bank)	*Aberdeen*	2·37	4·09	104	173	·78	15	20
Aberdeen (Cranford)	,,	2·05	3·70	94	180	·87	14	20
Gordon Castle	*Moray*	1·75	4·07	103	232	1·02	15	22
Fort William (Atholl Bank)	*Inverness*	4·47	2·54	65	57	·55	14	16
Alness (Ardross Castle)	*Ross*	2·42	4·01	102	166	1·23	15	19
Loch Torridon (Bendamph)	,,	5·22	5·74	146	110	·89	15	19
Stornoway	,,	3·03	2·56	65	84	·38	14	22
Loch More (Achfary)	*Sutherland*	4·85	6·08	154	125	1·04	15	22
Wick	*Caithness*	1·99	3·41	87	171	·90	15	20
Glanmire (Lota Lodge)	*Cork*	2·80	3·52	89	126	1·17	14	18
Killarney (District Asylum)	*Kerry*	3·31	3·31	84	100	·80	14	22
Waterford (Brook Lodge)	*Waterford*	2·54	2·71	69	107	·95	14	15
Nenagh (Castle Lough)	*Tipperary*	2·51	3·14	80	125	1·35	14	21
Ennistymon House	*Clare*	2·75	..	..	..	..	..	..
Gorey (Courtown House)	*Wexford*	2·19	3·29	84	150	1·20	14	16
Abbey Leix (Blandsfort)	*Queen's Co.*	2·61	3·65	93	140	1·05	14	19
Dublin (FitzWilliam Square)	*Dublin*	1·90	2·28	58	120	·56	14	20
Mullingar (Belvedere)	*Westmeath*	2·37	2·85	72	120	1·01	14	13
Crossmolina (Enniscoe)	*Mayo*	3·14	..	..	..	..	..	..
Collooney (Markree Obsy.)	*Sligo*	2·66	4·29	109	161	1·18	14	22
Seaforde	*Down*	2·62	4·68	119	179	1·57	14	15
Ballymena (Harryville)	*Antrim*	2·64	4·00	102	151	1·00	15	18
Omagh (Edenfel)	*Tyrone*	2·63	3·71	94	141	·87	14	16
Letterkenny Asylum	*Donegal*	2·80	4·24	108	151	1·38	14	19

Supplementary Rainfall, April 1922.

Div.	STATION.	RAIN. in.	RAIN. mm.	Div.	STATION.	RAIN. in.	RAIN. mm.
II.	Ramsgate	1·73	44	XII.	Langholm, Drove Rd.	2·21	56
,,	Sevenoaks, Speldhurst	3·40	86	XIII.	Ettrick Manse	4·24	107
,,	Hailsham Vicarage...	3·21	81	,,	North Berwick Res. ...	1·93	49
,,	Totland Bay, Aston Ho.	2·88	73	,,	Edinburgh, Royal Ob.	1·51	39
,,	Ashley, Old Manor Ho.	4·21	107	XIV.	Biggar...............	2·09	53
,,	Grayshott..........	4·46	113	,,	Leadhills	4·68	119
,,	Ufton Nervet........	3·23	82	,,	Kilmarnock, Agric. Coll.	2·19	55
III.	Harrow Weald, Hill Ho.	2·95	75	XV.	Dougarie Lodge.......	3·90	99
,,	Pitsford, Sedgebrook..	3·05	77	,,	Oban...............	3·13	79
,,	Chatteris, The Priory.	2·67	68	,,	Holy Loch, Ardnadam	..	..
IV.	Elsenham, Gaunts End	2·72	69	,,	Tiree Cornaigmore....	..	..
,,	Lexden, Hill House ..	2·42	61	XVI.	Loch Venachar	3·35	85
,,	Aylsham, Rippon Hall	3·53	90	,,	Glenquey Reservoir ...	2·50	63
,,	Swaffham...........	1·98	50	,,	Loch Rannoch, Dall...	2·09	53
V.	Devizes, Highclere ...	3·46	88	,,	Blair Atholl	2·25	57
,,	Weymouth	3·01	76	,,	Coupar Angus....... .	1·48	38
,,	Ashburton, Druid Ho.	5·93	151	,,	Montrose Asylum	2·37	60
,,	Cullompton	3·28	83	XVII.	Logie Coldstone, School	3·56	90
,,	Hartland Abbey	3·73	95	,,	Fyvie Castle..........	3·73	95
,,	Penzance, Morrab Gden.	3·45	88	,,	Grantown-on-Spey ...	5·04	128
,,	St. Austell, Trevarna.	4·57	116	XVIII.	Kingussie, Fasnakyle..	2·70	69
,,	Crewkerne Merefield Ho	3·54	90	,,	Fort Augustus........	1·94	49
VI.	Clifton College	2·62	67	,,	Loch Quoich, Loan ...	7·80	198
,,	Ledbury, Underdown.	2·63	67	,,	Fortrose	1·39	35
,,	Shifnal, Hatton Grange	2·16	55	,,	Faire-na-Squir........	..	..
,,	Ashbourne, Mayfield.	2·51	64	,,	Skye, Dunvegan	4·24	108
,,	Barnt Green, Upwood	3·07	78	XIX.	Loch Carron, Plockton.	2·66	68
,,	Blockley, Upton Wold	3·67	93	,,	Dornoch, St. Gilbert's .	2·19	56
VII.	Leicester, Town Hall Sq.	2·64	67	,,	Tongue Manse	4·41	112
,,	Grantham, Saltersford	2·94	75	,,	Melvich Schoolhouse ..	3·77	96
,,	Louth, Westgate	1·96	50	XX.	Dunmanway Rectory..	3·74	95
,,	Mansfield, West Bank	3·38	86	,,	Mitchelstown Castle...	3·33	85
VIII.	Nantwich, Dorfold Hall	2·42	61	,,	Gearahameen	6·20	157
,,	Bolton, Queen's Park.	2·49	63	,,	Darrynane Abbey	4·04	103
,,	Lancaster, Strathspey.	1·91	49	,,	Cashel, Ballinamona...	2·41	61
IX.	Wath-upon-Dearne...	2·92	74	,,	Roscrea, Timoney Pk..	2·82	72
,,	Bradford, Lister Park.	3·48	88	,,	Ballybunion..........	2·24	57
,,	West Witton.........	3·15	80	,,	Broadford, Hurdlesto'n	2·85	72
,,	Scarborough, Scalby..	1·83	47	XXI.	Kilkenny Castle.......	2·14	54
,,	Middlesbro', Albert Pk.	1·33	34	,,	Rathnew, Clonmannon	2·89	73
,,	Mickleton...........	3·40	86	,,	Hacketstown Rectory .	3·23	82
X.	Bellingham	2·06	52	,,	Balbriggan, Ardgillan .	2·69	68
,,	Ilderton, Lilburn	2·10	53	,,	Drogheda	2·65	67
,,	Orton...............	2·88	73	,,	Athlone, Twyford	2·84	72
XI.	Llanfrechfa Grange ..	..	..	XXII.	Castle Forbes Gdns....	2·43	62
,,	Treherbert, Tyn-y-waun	5·75	146	,,	Ballynahinch Castle...	4·82	122
,,	Carmarthen Friary ..	3·00	76	,,	Galway Grammar Sch.	3·28	83
,,	Lampeter, Falcondale	4·19	106	XXIII.	Westport House	3·56	90
,,	Cray Station	5·00	127	,,	Enniskillen, Portora...	2·81	71
,,	B'ham W.W., Tyrmyndd	4·55	116	,,	Armagh Observatory ..	3·09	78
,,	Lake Vyrnwy.......	3·47	88	,,	Warrenpoint	3·16	80
,,	Llangynhafal, P. Drâw	2·82	72	,,	Belfast, Cave Hill Rd..	3·73	95
,,	Oakley Quarries	4·38	111	,,	Glenarm Castle	5·19	132
,,	Dolgelly, Bryntirion..	3·33	85	,,	Londonderry, Creggan.	3·80	97
,,	Snowdon, L. Llydaw.	8·97	228	,,	Sion Mills...........	3·49	89
,,	Lligwy	2·16	55	,,	Milford, The Manse ...	3·88	99
XII.	Stoneykirk, Ardwell Ho.	2·81	71	,,	Narin, Kiltoorish	3·13	79
,,	Carsphairn, Shiel.....	5·29	134	,,	Killybegs, Rockmount .	3·56	90

Correction—Gearahameen for February, "15·00/381."

Climatological Table for the

STATIONS	PRESSURE: Mean M.S.L. mb.	PRESSURE: Diff. from Normal mb.	TEMPERATURE Absolute: Max. °F.	Absolute: Date	Absolute: Min. °F.	Absolute: Date	Mean Values: Max. °F.	Mean Values: Min. °F.	Mean Values: ½ max. and min. °F.	Mean Values: Diff. from Normal °F.
London, Kew Observatory	1018·8	+4·6	58	1	23	11	45·5	35·5	40·5	−3·5
Gibraltar	1016·8	+0·3	75	4	48	28, 29	67·0	55·9	61·5	+1·2
Malta	1015·2	−0·5	74	5	47	10	65·6	59·1	62·3	−0·8
Sierra Leone	1011·9	+0·8	92	7	70	30	87·1	73·8	80·5	−0·7
Lagos, Nigeria	1012·5	+1·7	89	1, 9	73	4	87·0	76·1	81·5	+0·2
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1009·9	+0·9	97	12	56	3	83·1	65·3	74·2	−0·9
Salisbury, Rhodesia	1010·1	+0·1	99	10	49	1	84·7	55·7	70·2	−0·7
Cape Town	1016·1	+0·4	89	25	49	12	75·6	57·4	66·5	+3·4
Johannesburg	1013·1	+0·3	82	10	36	13	70·8	51·9	61·3	−2·1
Mauritius	..	..	..	..	..	..	..	..	..	..
Bloemfontein	..	..	89	18	39	13	79·4	53·5	66·5	−1·9
Calcutta, Alipore Obsy.	1014·6	+1·3	86	8	58	19	82·6	63·0	72·8	−0·3
Bombay	1013·1	+1·2	91	1	71	29	87·5	73·1	80·3	0·0
Madras	1013·6	+1·9	87	18	63	10	85·1	69·8	77·5	−1·2
Colombo, Ceylon	1012·1	+2·0	91	14	70	15	88·2	73·1	80·7	+0·4
Hong Kong	1017·6	0·0	82	21	59	27	75·5	65·6	70·5	+0·8
Sandakan	..	..	91	13	74	sev.	87·7	75·4	81·5	+0·5
Sydney	1013·4	−0·3	90	5	53	8	76·8	61·7	69·3	+2·3
Melbourne	1012·7	−1·4	100	18	47	22	73·0	54·5	63·7	+2·4
Adelaide	1013·8	−1·3	108	18	46	21	80·0	57·4	68·7	+1·8
Perth, Western Australia	1015·2	−0·1	86	7	50	5, 19	73·9	55·5	64·7	−1·0
Coolgardie	1012·7	−0·4	98	29	45	19	83·4	54·5	68·9	−1·9
Brisbane	1014·5	+0·2	91	30	61	1	83·4	65·9	74·7	+1·2
Hobart, Tasmania	1008·3	−1·0	96	17	43	20	70·1	51·3	60·7	+3·5
Wellington, N.Z.	1011·2	−0·4	71	8	38	2	61·8	49·2	55·5	−1·4
Suva, Fiji	1011·8	+0·7	87	26	61	13	83·9	67·9	75·9	−1·3
Kingston, Jamaica	1013·9	+1·2	90	9	67	17	87·6	70·7	79·1	−0·2
Grenada, W.I.	1012·3	+1·7	89	11, 12, 16	73	6, 16, 23	85·4	75·0	80·2	+0·9
Toronto	1018·0	+1·2	62	19	21	23	42·0	30·7	36·3	0·0
Winnipeg	1019·9	+3·2	46	3	14	19, 21, 22	24·5	12·0	18·3	−2·5
St. John, N.B.	1016·6	+2·7	54	1	11	27	37·2	26·5	31·9	−4·8
Victoria, B.C.	1015·1	−0·4	58	4	24	21	47·3	40·2	43·7	−0·7

LONDON, KEW OBSERVATORY.—Mean speed of wind 6·1 mi/hr; 1 day with snow, 16 days with fog. † Wet Bulb Thermometer broken.

GIBRALTAR.—2 days with fog, 2 days with gale.

MALTA.—Wind direction variable. 2 days with hail, 3 days with thunder heard, 1 day with fog.

SIERRA LEONE.—Calms predominate. 7 days with thunder heard, 2 days with gale.

MADRAS.—1 day with thunder heard.

MELBOURNE :—

September 1921	1016·4	+0·6	75	6	38	4	65·3	46·3	55·8	+1·8

LAGOS corrected values	Feb. 1921	..	..	..	..	..	..	88·2	..	82·7	+0·6
	March 1921	1009·8	+0·4	..	..	..	..	89·4	..	83·5	+0·6
	April 1921	..	..	..	..	..	..	91·3	..	84·1	+1·8

British Empire, November 1921.

TEMPERATURE Mean Wet Bulb. °F.	TEMPERATURE Absolute Min. on Grass °F.	Relative Humidity %	Mean Cloud Am'nt 0–10	PRECIPITATION Amount in.	PRECIPITATION Amount mm.	PRECIPITATION Diff. from Normal mm.	PRECIPITATION Days	BRIGHT SUNSHINE Hours per day	BRIGHT SUNSHINE Percentage of possible	STATIONS
..†	16	..†	7·1	1·70	43	– 13	8	1·2	14	London, Kew Observatory.
58·1	41	84	4·3	5·25	133	– 28	9	..	..	Gibraltar.
57·7	39	79	5·6	3·87	98	+ 17	14	5·3	52	Malta.
76·1	..	78	5·5	9·35	237	+102	15	..	..	Sierra Leone.
76·5	71	83	8·9	3·35	85	+ 19	11	..	..	Lagos, Nigeria.
..	..	..	..	..	..	..	..	..	..	Kaduna, Nigeria.
..	..	74	4·9	3·41	87	– 55	8	..	..	Zomba, Nyasaland.
61·9	..	56	..	2·73	69	– 23	9	..	..	Salisbury, Rhodesia.
61·6	..	60	4·1	0·51	13	– 14	2	..	..	Cape Town.
54·1	35	66	5·9	3·57	91	– 17	15	7·4	56	Johannesburg.
..	..	..	..	..	..	..	..	..	..	Mauritius.
56·6	..	54	5·1	1·36	35	– 23	14	..	..	Bloemfontein.
67·2	50	50	1·2	0·00	0	– 14	0*	..	..	Calcutta, Alipore Obsy.
71·4	59	62	1·4	0·00	0	– 10	0*	..	..	Bombay.
..	..	79	4·0	1·77	45	–280	2*	..	..	Madras.
75·8	64	65	5·3	3·46	88	–219	14	..	..	Colombo, Ceylon.
60·9	..	58	6·1	0·22	6	– 30	6	6·1	55	Hong Kong.
..	..	..	..	8·60	218	–155	13	..	..	Sandakan.
64·5	44	69	5·6	3·02	77	+ 3	12	6·4	46	Sydney.
58·6	40	62	6·1	2·61	66	+ 8	6	..	..	Melbourne.
57·6	37	45	5·2	2·20	56	+ 26	8	8·4	60	Adelaide.
58·9	41	61	4·6	0·84	21	+ 1	10	9·4	69	Perth, Western Australia.
57·8	..	35	3·7	0·20	5	– 12	1	..	..	Coolgardie.
69·1	55	69	3·8	3·24	82	– 13	9	..	..	Brisbane.
53·0	34	57	6·0	0·33	8	– 57	9	8·3	57	Hobart, Tasmania.
51·3	27	74	7·4	3·55	90	– 2	14	6·4	45	Wellington, N.Z.
73·8	..	86	..	20·27	515	+273	14	..	..	Suva, Fiji.
..	..	75	5·1	0·14	4	– 76	6	..	..	Kingston, Jamaica.
75·2	..	75	3·3	4·72	120	– 88	23	..	..	Grenada, W.I.
33·3	19	82	7·2	1·45	37	– 38	17	..	..	Toronto.
16·7	..	81	7·4	0·86	22	– 2	15	..	..	Winnipeg.
29·9	11	80	8·0	6·79	172	+ 60	9	..	..	St. John, N.B.
41·6	23	90	8·2	6·09	155	– 9	22	..	..	Victoria, B.C.

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.

COLOMBO, CEYLON.—Prevailing wind direction N, mean speed 4·8 mi/hr. 4 days with thunder heard.

HONG KONG.—Prevailing wind direction ENE, mean speed 12·5 mi/hr.

HOBART, TASMANIA.—Mean temperature highest since 1872 (63·1).

WELLINGTON, N.Z.—1 day with hail.

SUVA, FIJI.—1 day with thunder heard.

GRENADA, W.I.—Prevailing wind direction E.

52·1	32	68	5·6	3·63	92	+ 31	14	..	..	MELBOURNE :— September 1921
..	..	..	..	..	..	..	..	..	..	Feb. 1921 (LAGOS corrected values.)
80·7	..	83	..	3·42	87	– 9	..	..	..	March 1921 (LAGOS corrected values.)
..	..	..	..	..	..	..	..	..	..	April 1921 (LAGOS corrected values.)

(*Continued from p.* 111.)

It was reported on the 6th that the ice in Reval Harbour (Esthonia) had broken up sufficiently to allow shipping movements without the assistance of an icebreaker. A telegram from Riga received in Paris on the 11th stated that a terrible catastrophe had occurred at Dvinsk through the breaking of the ice on the River Dvina. Great blocks of ice obstructed the river, which rose over 30 ft. and flooded the town, causing the death of about 1,000 persons The ice barrier was finally destroyed by gunfire. The usual date for the breaking of the ice is about March 29th. Navigation on the Volga was opened a few days before the end of the month.

A violent snowstorm was experienced at Hammerfest on the 11th.

About 55 mm. of rainfall fell in south-western Alberta during April. Navigation on the St. Lawrence was opened as far as Montreal on the 12th.

A series of tornadoes passed over various villages in Illinois, Indiana and Arkansas on the 17th; 20 persons were killed and large numbers injured. About a week previously a severe tornado swept over Texas and Oklahoma. The casualties on this occasion are believed to be numerous. Floods occurred with loss of life at Dallas (Texas). The Mississippi remained in a dangerously flooded state and Congress has voted $1,000,000 for the taking of immediate steps to control its waters.

A violent blizzard swept over the Mount Everest Expedition on the afternoon of the 8th, a few hours after it had left Phari Dzong, but there were no serious results of any kind.

The dry spell which has been causing anxiety to farmers in some parts of Australia was broken towards the end of April by rains in South Australia and New South Wales. Unusually high temperatures for the time of year were experienced during Easter at Sydney and Melbourne.

The special message from Brazil states that rainfall was excessive over the northern region, the excess being on the average 180 mm. above normal, but 300 to 600 mm. in certain stations. There were destructive floods in Amazonas, Ceara and Alagoas states. Rainfall was 20 mm. below normal in the centre and irregular in the south. The amount of sunshine was generally rather low but temperature was normal. The average pressure for April was 1·8 mb. above normal. Rice and cane plantations suffered from the floods. A severe storm occurred at Rio on the night of the 9th with high wind and much rain, which flooded portions of the town.

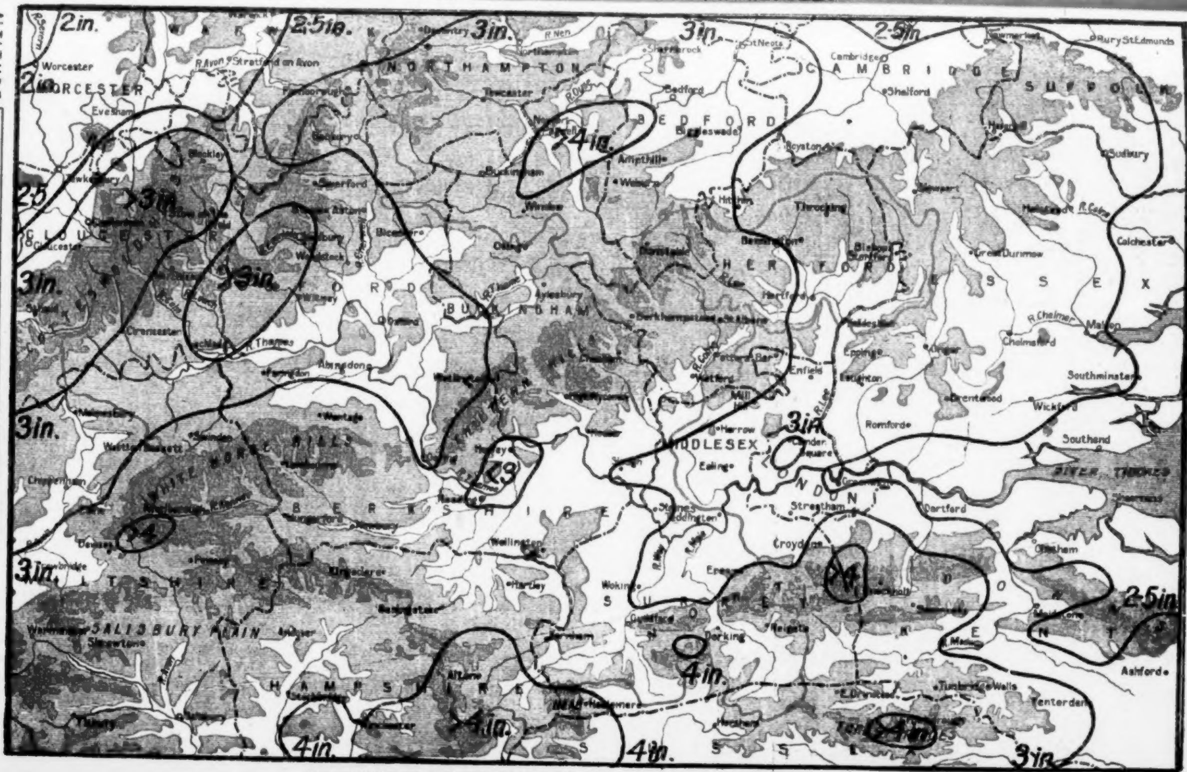
The rainfall of April was above the average for the period 1881–1915 nearly everywhere in the British Isles, the only exceptions being in the north-west of Great Britain. Isolated areas in Cornwall, Northamptonshire and in Morayshire recorded more than twice the average. The general distribution of rainfall was somewhat similar to that in April 1920. Falls of less than 50 mm. (2 in.) were confined mainly to the east coasts of England and Scotland between the Wash and Montrose, but a few stations in the Central Plain of Scotland also had less than this amount. Falls of more than 100 mm. (4 in.) were widespread, but the areas with more than 150 mm. (6 in.) were extremely restricted.

The total rainfall of the four months January to April in the south-east of England has been approximately 50 per cent. in excess of the average.

The general rainfall for April, expressed as a percentage of the average, was :—England and Wales, 155; Scotland, 126; Ireland, 136; British Isles, 141.

In London, Camden Square, the mean temperature for April was 44·1° F., or 3·9° F. below the average; the duration of rainfall, 75·2 hours; and the evaporation, 1·20 inch.

THAMES VALLEY RAINFALL —— APRIL, 1922.



*Watershed of River Thames above Teddington, and River Lee above Feildes Weir.

Isohyetals.

ALTITUDE SCALE

Below 250 feet	250 to 500 feet	500 to 1000 feet	Above 1000 feet

SCALE OF MILES

0 5 10 15 20

H.M. Stationery Office Press, Kingsway, W.C.2.

Ps.1870/521. Wt.69. D.P.I. 1000. 5/22.